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**TOLL ENRICHMENT URANIUM HEXAFLUORIDE:
NATURAL AND REACTOR RETURN FEED ANALYSES
AT ORGDP FOR CY 1981**

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TOLL ENRICHMENT URANIUM, HEXAFLUORIDE:
NATURAL AND REACTOR RETURN FEED ANALYSES
AT ORGDP FOR CY 1981

INTRODUCTION

The attached tables are summaries of the results of analyses performed at the Oak Ridge Gaseous Diffusion Plant (ORGDP) for defining adherence to Toll Enrichment and program feed specifications* for calendar year (CY) 1981. Also included are the results of analyses for metallic impurities for both the natural and reactor return feed materials, and for comparison, ORGDP product and tails for CY 1981. Such information can be useful for (1) reviewing vendor specification adherence, (2) specification review studies, and (3) establishing areas requiring special attention. This report is an addendum to K/TL/AT-58, Rev. 1 which presents like information for CY 1974 through CY 1980.

The following cylinder sampling schedule applied during CY 1981:

	Natural Feed [†]		Other
	Allied Chemical BNFL (United Kingdom)	Kerr-McGee Eldorado Comhurex (French)	Depleted, Enriched Reactor Returns
Sample rate	20%	100%	100%
Analysis required			
Full specification	50%	10%	100%
Modified specification [‡]	50%	90%	0%

[†] Does not include radiochemical analysis.

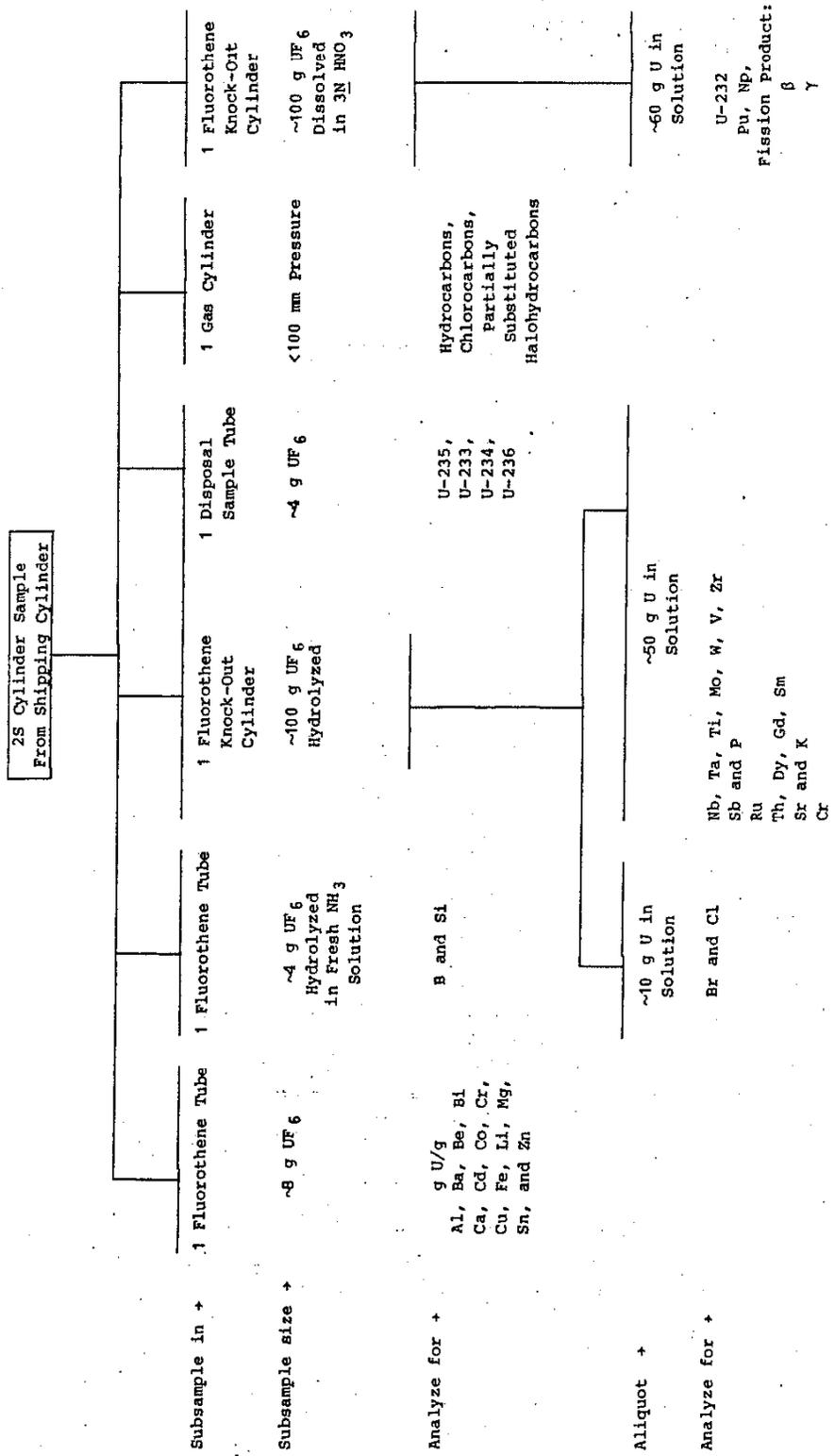
[‡] Includes U, ²³⁵U, Tm, Mo, and Cr.

Table 1 is a subsample flow diagram representing the number of samples obtained from the liquid UF₆ contained in any one sample cylinder. The table represents full specification analyses which are obtained on all feed material other than natural feed. Natural feed UF₆ is analyzed for all specifications indicated in Table 1 except the radiochemical measurements and minor uranium isotopes. Modified specifications for Cr and Mo are performed on subsamples obtained in a single fluorothene tube which is a deviation from Table 1.

Table 2 is a summary of the feed specifications. Included are the sample property analyzed, the specification level, units of results and the basis for the units, the analytical TECHMS procedure number, and a general description of the method.

*Federal Register Notices 32FR 16289-16291, November 29, 1967; 34FR 14039, September 4, 1969; 36FR 4563, March 9, 1971; and 36FR 118877-11878, June 22, 1971.

Table 1. Toll Enrichment Feed Specification Subsample Flow



0

Table 2. Toll Enrichment Feed Specifications
Including Procedure Numbers and Methods

Property	Specification Limits		Unit	Basis	Procedure Number ⁽¹⁾	Method Description ⁽²⁾
	Minimum	Maximum				
Uranium Hexafluoride	99.5		Percent	Weight	-	Calculation
Uranium	-		Percent	Weight	1800	Gravimetric
Cylinder vapor pressure at 200°F	Maximum		psia	Measured on shipping cylinder	-	TEMP: Thermocouple
	75					PRES: Transmitter
Hydrocarbons, chlorocarbons, partially substituted halohydrocarbons	0.01		Percent	mole	2106	Gas MS
Antimony	1		ppm	U	1001	CD/ES
Bromine	5		ppm	U	1808	Polarographic
Chlorine	100		ppm	U	1802	Colorimetric
Niobium	1		ppm	U	1009	CUP/ES
Phosphorus	50		ppm	U	1001	CD/ES
Ruthenium	1		ppm	U	1014	ZR/ES
Silicon	100		ppm	U	1006	CD/ES
Tantalum	1		ppm	U	1009	CUP/ES
Titanium	1		ppm	U	1009	CUP/ES
Elements forming nonvolatile fluorides	300		ppm	U	1001	CD/ES
Chromium	1500		ppm	235U	1005	Atomic Absorption
Molybdenum	200		ppm	235U	1824	Colorimetric
Tungsten	200		ppm	235U	1009	CUP/ES
Vanadium	200		ppm	235U	1009	CUP/ES
Uranium-233	500		ppm	235U	2113	Thermal Ionization MS
Uranium-232	0.110		ppm	235U	1609	Radiochemical
Boron equivalent cross section	8		ppm	U	2006 1013/1006	Calculation B: CD/ES
Fission product gamma	20		Percent of Aged Natural U		1608	Radiochemical
Fission product beta	10				1608	Radiochemical
Transuranic alpha	1500		d/m/g	U	1606/1607	Np/Pu Radiochemical
Uranium-234	-		Percent	Weight	2114	Thermal Ionization MS
Uranium-235	-		Percent	Weight	2118	Relative UF ₆ Gas MS
Uranium-236	-		Percent	Weight	2114	Thermal Ionization MS
Technetium	-		ppm	U	1610	Radiochemical

(1) TECHMS Analytical Procedure Numbers

(2) CUP/ES: Cupferron Extraction and Emission Spectroscopy
 CD/ES: Carrier Distillation and Emission Spectroscopy
 FP/ES: Fluoride Precipitation and Emission Spectroscopy
 ZR/ES: Zinc Reduction and Emission Spectroscopy
 MS: Mass Spectrometry

The average purity and ^{235}U of the UF_6 for natural and reactor return feed by individual vendor, enriched feed, ORGDP product, and ORGDP tails is given in Table 3 for CY 1981. Included in the table are the total number of cylinders received by ORGDP from each vendor, the number sampled and analyzed for modified specifications, and the number sampled and analyzed for full natural feed specifications during CY 1981.

SUMMARY

Presented in Table 4 are those specification properties which were observed to be present in toll enrichment feed during CY 1981. Both natural and reactor return feed by individual vendor are included, as are also enriched feed, ORGDP product, and ORGDP tails for comparison. Specifications were exceeded by Eldorado for Mo and cylinder pressure, and by Kerr-McGee for total nonvolatile fluoride, Mo, and cylinder pressure.

Presented in Table 5 are the nonvolatile metallic fluorides as determined by carrier distillation/emission spectroscopy (Quantometer) which were observed in natural, reactor return, and enriched feed, and in ORGDP product and tails UF_6 . The common elements observed (Cu, Fe, Mg, and Ni) are expected due to UF_6 contact with materials used during shipping, sampling, and subsampling.

Table 6 is a summary of average purity and ^{235}U results of natural feed for CY 1981. There is little difference in the purity levels among vendors or years (generally within 0.01 wt % UF_6) except for CY 1980. There is little difference in the ^{235}U levels among vendors or years, with the vendors being in the following descending order for CY 1981: Eldorado, BNFL, Allied Chemical, Kerr-McGee, and Comhurex.

SPECIFICATION ANALYSES

NATURAL FEED

The following tables provide information concerning the required measurement, specification level, units and basis of results, the number of samples analyzed, the arithmetic average of observed results (less than values are excluded from averages), the range of results, and the number of results exceeding specification for each measurement. Specifications were exceeded for Mo and cylinder pressure by Eldorado, and for nonvolatile fluoride, Mo, and cylinder pressure by Kerr-McGee.

The following tables are included:

Table Number	Vendor
7	Allied Chemical
8	BNFL
9	Comhurex
10	Eldorado Nuclear
11	Kerr-McGee

Table 3. UF₆ and ²³⁵U Observed in CY 1981

	Number of Cylinders Received	Samples Analyzed		Wt & UF ₆	Wt & ²³⁵ U
		Modified Specifications	Full Specifications		
<u>Natural Feed</u>					
Allied Chemical	187	19	14	99.971	0.71089
BNFL	36	2	6	99.966	0.71097
Comhurex	52	41	10	99.966	0.71082
Eldorado Nuclear	99	86	16	99.966	0.71110
Kerr-McGee	194	149	17	99.970	0.71086
Totals/Weighted Average	568	297	63	99.968	0.71092
<u>Reactor Returns Feed</u>					
Comhurex	42	-	53	99.959	1.0134
<u>Enriched Feeds</u>	18(1)	9(2)	-	99.943	2.7760
<u>ORGDP Tails</u>	-	15(2)	-	99.962	0.3950
<u>ORGDP Product</u>	-	-	9	99.944	2.8115

(1) Data includes 9 of the 18 cylinders. Six of the cylinders were vapor sampled for ²³⁵U only.

(2) Analyzed for UF₆, ²³⁵U, and metallic impurities only. Samples were from K-1131 during the period February through April 1981.

Table 4. Specification Impurities Observed in CY 1981

<u>Natural Feed</u>	<u>Cl</u>	<u>Si</u>	<u>TNV⁽³⁾</u>	<u>Mo</u>	<u>V</u>	<u>BEQ⁽²⁾</u>	<u>²³²U</u>	<u>γ</u>	<u>β</u>	<u>α</u>
Allied Chemical	x	x	x	x		x	[analyses for ²³² U, γ, β, and α are not performed for natural feed]			
BNFL	x	x	x	x		x				
Comhurex	x	x	x	x	x	x				
Eldorado Nuclear	x	x	x	x ⁽¹⁾	x	x				
Kerr-McGee	x	x	x ⁽¹⁾	x ⁽¹⁾		x				
<u>Reactor Returns</u>										
Comhurex	x	x	x	x		x	x	x	x	x
<u>Enriched Feed</u>	(Not available for specifications)									
<u>ORGDP Product</u>	x	x	x	x		x		x	x	x
<u>ORGDP Tails</u>	(Not available for specifications)									

(1) One or more results exceeded specifications

(2) Boron equivalent cross-section (BEQ)

(3) Total nonvolatile fluorides (TNV)

Table 5. Nonvolatile Fluorides Observed in CY 1981

<u>Natural Feed</u>	<u>Al</u>	<u>Ba</u>	<u>Be</u>	<u>Bi</u>	<u>Ca</u>	<u>Cd</u>	<u>Co</u>	<u>Cu</u>	<u>Fe</u>	<u>Li</u>	<u>Mg</u>	<u>Mn</u>	<u>Na</u>	<u>Ni</u>	<u>Pb</u>	<u>Sn</u>	<u>Zn</u>
Allied Chemical					x	x		x	x				x	x			
BNFL								x	x		x			x			
Comhurex					x	x		x	x		x		x	x	x		
Eldorado Nuclear					x	x		x	x		x	x	x	x	x	x	
Kerr-McGee	x				x			x	x		x	x	x	x	x		
<u>Reactor Returns</u>																	
Comhurex	x				x	x	x	x	x		x		x	x	x		
<u>Enriched Feed</u>						x		x	x				x	x			
<u>ORGDP Product</u>	x				x		x	x			x		x	x	x		
<u>ORGDP Tails</u>	x				x	x		x	x		x		x	x			

Table 6. Purity and ^{235}U Results Summary for Natural Feed by Vendor for 1975 Through 1981

	Average purity, Weight Percent UF_6						
	1975	1976	1977	1978	1979	1980	1981
Allied Chemical	99.982	99.971	99.981	99.981	99.975	99.957	99.971
BNFL	99.982	99.987	99.988	99.985	99.980	99.953	99.966
Comhurex	99.990	99.977	99.984	99.978	99.977	99.972	99.966
Eldorado Nuclear	99.992	99.990	99.980	99.978	99.975	99.955	99.966
Kerr-McGee	99.987	99.982	99.992	99.978	99.976	99.958	99.970

	Average ^{235}U , Weight Percentage						
	1975	1976	1977	1978	1979	1980	1981
Allied Chemical	0.71085	0.71097	0.71095	0.71092	0.71086	0.71090	0.71089
BNFL	0.71112	0.71117	0.71113	0.71107	0.71110	0.71105	0.71097
Comhurex	0.71095	0.71090	0.71070	0.71109	0.71016*	0.71080	0.71082
Eldorado Nuclear	0.71092	0.71106	0.71102	0.71101	0.71102	0.71096	0.71110
Kerr-McGee	0.71088	0.71082	0.71085	0.71085	0.71084	0.71084	0.71086

* Includes 3 of 16 results lower than 0.7103 wt % ^{235}U .

Table 7. Specification Analyses for Allied Chemical Natural Feed, CY-1981

Measurement	Feed Specification Level		Units	Basis	Number of Samples (2)	Average	Range	Number Exceeding Specification
	(1)	(2)						
Antimony	1		ppm	U	14	<1	All <1	0
Boron Equivalent Cross Section	8		ppm	U	14(5)	2.1	<1.8-2.6	0
Bromine	5		ppm	U	14	<5	All <5	0
Chlorine	100		ppm	U	14	34	20-67	0
Chromium	1500		ppm	235U	33	<700	All <700	0
Cylinder Pressure	75		PSIA	At 200°F	13	56.9	40-68	0
Hydrocarbons, etc.	0.01		Percent	Mole	14	<0.01	All <0.01	0
Molybdenum	200		ppm	235U	33(8)	116	<28-180	0
Niobium	1		ppm	U	14	<0.2	All <0.2	0
Nonvolatile Fluorides	300		ppm	U	33	40.8	4-183	0
Phosphorus	50		ppm	U	14	<20	All <20	0
Ruthenium	1		ppm	U	14	<1	All <1	0
Silicon	100		ppm	U	14(11)	7.0	<2-12	0
Tantalum	1		ppm	U	14	<0.3	All <0.3	0
Titanium	1		ppm	U	14	<0.3	All <0.3	0
Tungsten	200		ppm	235U	14	<70	All <70	0
Uranium	(3)		Percent	Weight	33	67.598	67.55-67.62	0
Uranium Hexafluoride	99.5		Percent	Weight	33	99.971	99.90-100	0
Uranium-235	0.7103		Percent	Weight	33	0.71089	0.7106-0.7111	0
Vanadium	200		ppm	235U	14	<42	All <42	0

(1) All levels are maximums except UF₆ and 235U which are minimums.

(2) The numbers in parentheses reflect the number of analyses in averages. Only quantified results used in averages, i.e., "less than" results are excluded.

(3) Not a specific specification.

Table 8. Specification Analyses for BNFL (British) Natural Feed, CY-1981

Measurement	Feed		Units	Basis	Number of Samples (2)	Average	Range	Number Exceeding Specification
	Specification Level (1)	Specification						
Antimony	1		ppm	U	6	<1	All <1	0
Boron Equivalent Cross Section	8		ppm	U	6(2)	2.1	<1.8-2.8	0
Bromine	5		ppm	U	6	<5	All <5	0
Chlorine	100		ppm	U	6	38.8	27-58	0
Chromium	1500		ppm	235U	8	<700	All <700	0
Cylinder Pressure	75		PSIA	At 200°F	1	68	68	0
Hydrocarbons, etc.	0.01		Percent	Mole	6	<0.01	All <0.01	0
Molybdenum	200		ppm	235U	8(1)	168	<28-168	0
Niobium	1		ppm	U	6	<0.2	All <0.2	0
Nonvolatile Fluorides	300		ppm	U	8	46.8	3-105	0
Phosphorus	50		ppm	U	6	<20	All <20	0
Ruthenium	1		ppm	U	6	<1	All <1	0
Silicon	100		ppm	U	6	6.1	2.5-11	0
Tantalum	1		ppm	U	6	<0.3	All <0.3	0
Titanium	1		ppm	U	6	<0.3	All <0.3	0
Tungsten	200		ppm	235U	6	<70	All <70	0
Uranium	(3)		Percent	Weight	8	67.595	67.58-67.61	0
Uranium Hexafluoride	99.5		Percent	Weight	8	99.966	99.94-99.99	0
Uranium-235	0.7103		Percent	Weight	8	0.71097	0.7107-0.7112	0
Vanadium	200		ppm	235U	6	<42	All <42	0

(1) All levels are maximums except UF₆ and 235U which are minimums.

(2) The numbers in parentheses reflect the number of analyses in averages. Only quantified results used in averages, i.e., "less than" results are excluded.

(3) Not a specific specification.

Table 9. Specification Analyses for Comburex Natural Feed, CY 1981

Measurement	Feed			Average	Range	Number Exceeding Specification
	Specification Level (1)	Units	Basis			
Antimony	1	ppm	U	<1	All <1	0
Boron Equivalent Cross Section	8	ppm	U	2.5	<1.8-3.0	0
Bromine	5	ppm	U	<5	All <5	0
Chlorine	100	ppm	U	42.1	23-82	0
Chromium	1500	ppm	235U	<700	All <700	0
Cylinder Pressure	75	PSIA	At 200°F	60.8	48-68	0
Hydrocarbons, etc.	0.01	Percent	Mole	<0.01	All <0.01	0
Molybdenum	200	ppm	235U	114	<70-200	0
Niobium	1	ppm	U	<0.2	All <0.2	0
Nonvolatile Fluorides	300	ppm	U	28.0	6-80	0
Phosphorus	50	ppm	U	<20	All <20	0
Ruthenium	1	ppm	U	<1	All <1	0
Silicon	100	ppm	U	8.8	<2-23	0
Tantalum	1	ppm	U	<0.3	All <0.3	0
Titanium	1	ppm	U	<0.3	All <0.3	0
Tungsten	200	ppm	235U	<70	All <70	0
Uranium	(3)	Percent	Weight	67.595	67.55-67.62	0
Uranium Hexafluoride	99.5	Percent	Weight	99.966	99.90-100	0
Uranium-235	0.7103	Percent	Weight	0.71082	0.7095-0.7111	0
Vanadium	200	ppm	235U	42	<42-42	0

(1) All levels are maximums except UF₆ and 235U which are minimums.

(2) The numbers in parentheses reflect the number of analyses in averages. Only quantified results used in averages, i.e., "less than" results are excluded.

(3) Not a specific specification.

Table 10. Specification Analyses for Eldorado Nuclear Natural Feed, CY 1981

Measurement	Feed		Units	Basis	Number of Samples (2)	Average	Range	Number Exceeding Specification
	Specification Level (1)	Number Exceeding Specification						
Antimony	1		ppm	U	16	<1	All <1	0
Boron Equivalent Cross Section	8		ppm	U	16(3)	2.6	<1.8-2.8	0
Bromine	5		ppm	U	16	<5	All <5	0
Chlorine	100		ppm	U	16	39.2	21-72	0
Chromium	1500		ppm	235U	102	<700	All <700	0
Cylinder Pressure	75		PSIA	At 200°F	24	59.3	38-78	1
Hydrocarbons, etc.	0.01		Percent	Mole	16	<0.01	All <0.01	0
Molybdenum	200		ppm	235U	102(100)	180	<70-410	25
Niobium	1		ppm	U	16	<0.2	All <0.2	0
Nonvolatile Fluorides	300		ppm	U	102	41.9	2-267	0
Phosphorus	50		ppm	U	16	<20	All <20	0
Ruthenium	1		ppm	U	16	<1	All <1	0
Silicon	100		ppm	U	16(13)	7.0	<2-30	0
Tantalum	1		ppm	U	16	<0.3	All <0.3	0
Titanium	1		ppm	U	16	<0.3	All <0.3	0
Tungsten	200		ppm	235U	16	<70	All <70	0
Uranium	(3)		Percent	Weight	102	67.595	67.57-67.62	0
Uranium Hexafluoride	99.5		Percent	Weight	102	99.966	99.93-100	0
Uranium-235	0.7103		Percent	Weight	102	0.71110	0.7108-0.7113	0
Vanadium	200		ppm	235U	16(3)	112	<42-154	0

(1) All levels are maximums except UF₆ and 235U which are minimums.

(2) The numbers in parentheses reflect the number of analyses in averages. Only quantified results used in averages, i.e., "less than" results are excluded.

(3) Not a specific specification.

Table 11. Specification Analyses for Kerr-McGee Natural Feed, CY 1981

Measurement	Feed Specification Level (1)	Units	Basis	Number of Samples (2)	Average	Range	Number Exceeding Specification
Antimony	1	ppm	U	17	<1	All <1	0
Boron Equivalent Cross Section	8	ppm	U	17(8)	2.8	<1.8-5.0	0
Bromine	5	ppm	U	17	<5	All <5	0
Chlorine	100	ppm	U	17	44.4	16-70	0
Chromium	1500	ppm	235U	166	<700	All <700	0
Cylinder Pressure	75	PSIA	At 200°F	15	57.2	40-80	1
Hydrocarbons, etc.	0.01	Percent	Mole	17	<0.01	All <0.01	0
Molybdenum	200	ppm	235U	166(101)	113	<70-280	1
Niobium	1	ppm	U	17	<0.2	All <0.2	0
Nonvolatile Fluorides	300	ppm	U	166(165)	39.0	<1-306	1
Phosphorus	50	ppm	U	17	<20	All <20	0
Ruthenium	1	ppm	U	17	<1	All <1	0
Silicon	100	ppm	U	17(11)	16.5	<2-58	0
Tantalum	1	ppm	U	17	<0.3	All <0.3	0
Titanium	1	ppm	U	17	<0.3	All <0.3	0
Tungsten	200	ppm	235U	17	<70	All <70	0
Uranium	(3)	Percent	Weight	166	67.598	67.55-67.62	-
Uranium Hexafluoride	99.5	Percent	Weight	166	99.970	99.90-100	0
Uranium-235	0.7103	Percent	Weight	166	0.71086	0.7106-0.7112	0
Vanadium	200	ppm	235U	17	<42	All <42	0

(1) All levels are maximums except UF₆ and 235U which are minimums.

(2) The numbers in parentheses reflect the number of analyses in averages. Only quantified results used in averages, i.e., "less than" results are excluded.

(3) Not a specific specification.

REACTOR RETURNS

Table 12 presents data for reactor returns from Conhurex for CY 1981. The same format is used as is used for natural feed except radiochemical and minor isotope results are included. Although no specifications were exceeded, results for Mo and ^{232}U approached the specification limit.

ENRICHED FEED

Nine enriched feed cylinders were sampled and analyzed for UF_6 , U, nonvolatile fluorides, and ^{235}U only. The following data was observed:

Measurement	Units	Basis	Average	Range
Uranium Hexafluoride	Percent	Weight	99.943	99.93-99.97
Uranium	Percent	Weight	67.571	67.57-67.60
Nonvolatile Fluorides	ppm	U	13	2-40
Uranium-235	Percent	Weight	2.7760	1.583-3.373

ORGDP PRODUCT

Table 13 presents data for ORGDP product monitored samples for CY 1981. The same format is used as is used for reactor returns.

ORGDP TAILS

Fifteen special tails cylinders for CY 1981 were sampled and analyzed for UF_6 , U, nonvolatile fluorides, and ^{235}U only. The following data was observed:

Measurement	Units	Basis	Average	Range
Uranium Hexafluoride	Percent	Weight	99.962	99.85-100
Uranium	Percent	Weight	67.592	67.52-67.62
Nonvolatile Fluorides	ppm	U	41	11-88
Uranium-235	Percent	Weight	0.3950	0.3621-0.4099

Table 12. Specification Analyses for Comhurex (French) Reactor Returns, CY 1981

Measurement	Feed		Units	Basis	Number of Samples (2)	Average	Range	Number Exceeding Specification
	Specification Level (1)							
Antimony	1		ppm	U	53	<1	All <1	0
Boron Equivalent Cross Section	8		ppm	U	53 (13)	3.8	<1.8-6.0	0
Bromine	5		ppm	U	53	<5	All <5	0
Chlorine	110		ppm	U	53	31.5	12-80	0
Chromium	1500		ppm	235U	53	<630	All <630	0
Cylinder Pressure	75		PSIA	At 200°F	7	57.7	51-68	0
Fission Product Gamma	20		Percent of Aged		53 (7)	6.7	<5-9.4	0
Fission Product Beta	10		Natural U		53 (23)	0.44	<0.1-2.0	0
Hydrocarbons, etc.	0.01		Percent Mole		53	<0.01	All <0.01	0
Molybdenum	200		ppm	235U	53 (8)	110	<75-200	0
Niobium	1		ppm	U	53	<0.2	All <0.2	0
Nonvolatile Fluorides	200		ppm	U	53	36.6	7-199	0
Phosphorus	50		ppm	U	53	<20	All <20	0
Ruthenium	1		ppm	U	53	<1	All <1	0
Silicon	100		ppm	U	53 (48)	9.4	<2-70	0
Tantalum	1		ppm	U	53	<0.3	All <0.3	0
Titanium	1		ppm	U	53	<0.3	All <0.3	0
Transuranic Alpha	1500		d/m/g	U	53 (44)	6.3	<1.0-30.8	0
Tungsten	200		ppm	235U	53	<60	All <60	0
Uranium	(3)		Percent Weight		53	67.590	67.57-67.62	-
Uranium Hexafluoride	99.5		Percent Weight		53	99.959	99.93-100	0
Uranium-232	0.110		ppm	235U	53 (47)	0.050	<0.01-0.096	0
Uranium-233	500		ppm	235U	53	<500	All <500	0
Uranium-234	(3)		Percent Weight		53	0.0137	0.0056-0.017	-
Uranium-235	(3)		Percent Weight		53	1.0134	0.7966-1.1212	-
Uranium-236	(3)		Percent Weight		53	0.239	0.0036-0.34	-
Vanadium	200		ppm	235U	53	<40	All <40	0

(1) All levels are maximums except UF₆ and 235U which are minimums.

(2) The numbers in parentheses reflect the number of analyses in averages. Only quantified results used in averages, i.e., "less than" results are excluded.

(3) Not a specific specification.

Table 13. Analyses for ORGDP Product, CY 1981

Measurement	Specification Level (1)	Feed	Units	Basis	Number of Samples (2)	Average	Range
Antimony	1		ppm	U	9	<1	ALL <1
Boron Equivalent Cross Section*	8		ppm	U	9(2)	2.45	<1.8-2.5
Bromine	5		ppm	U	9	<5	ALL <5
Chlorine	100		ppm	U	9	43.1	26-83
Chromium	1500		ppm	235U	9	<200	ALL <200
Cylinder Pressure	75		PSIA	At 200°F	1	60	-
Fission Product Gamma	20		Percent of Aged		9(2)	6.3	<5-7
Fission Product Beta	10		Natural U		9(3)	1.85	<0.1-3.6
Hydrocarbons, etc.	0.01		Percent Mole		9	<0.01	ALL <0.01
Molybdenum	200		ppm	235U	9(3)	81	<7-112
Niobium	1		ppm	U	9	<0.2	ALL <0.2
Nonvolatile Fluorides	300		ppm	U	9	33.4	11-64
Phosphorus	50		ppm	U	9	<20	ALL <20
Ruthenium	1		ppm	U	9	<1	ALL <1
Silicon	100		ppm	U	9	12.1	2-45
Tantalum	1		ppm	U	9	<0.3	ALL <0.3
Titanium	1		ppm	U	9	<0.3	ALL <0.3
Transuranic Alpha	1500		d/m/g	U	9(4)	4.2	<0.1-5.0
Tungsten	200		ppm	235U	9	<20	ALL <20
Uranium	(3)		Percent Weight		9	67.581	67.56-67.61
Uranium Hexafluoride	99.5		Percent Weight		9	99.944	99.91-99.99
Uranium-232	0.110		ppm	235U	9	<0.005	ALL <0.005
Uranium-233	500		ppm	235U	9	<100	ALL <100
Uranium-234	(3)		Percent Weight		9	0.0232	0.019-0.034
Uranium-235	(3)		Percent Weight		9	2.8115	2.4116-3.3318
Uranium-236	(3)		Percent Weight		9(7)	0.0046	0.0011-0.016
Vanadium	200		ppm	235U	9	<12	ALL <12

*Includes Th at <1, Dy at <0.2, Gd at <0.2, and Sm at <0.4.

(1) All levels are maximums except UF₆ and 235U which are minimums.

(2) The numbers in parentheses reflect the number of analyses in averages. Only quantified results used in averages, i.e., "less than" results are excluded.

(3) Not a specific specification.

SUPPLEMENTAL ANALYSES FOR CY 1981

The following tables provide a summary of results of nonvolatile metallic impurities in natural feed, reactor returns, enriched feed, and ORGDP product and tails UF₆. All results were obtained from carrier distillation/emission spectroscopy (Quantometer), except Dy, Gd, Sm, Tc, and Th. The following tables are included:

<u>Table Number</u>	<u>Material Source</u>
<u>Natural Feed</u>	
14	Allied Chemical
15	BNFL
16	Comhurex
17	Eldorado Nuclear
18	Kerr-McGee
<u>Reactor Return Feed</u>	
19	Comhurex
<u>Enriched Feed</u>	
20	--
<u>ORGDP Product</u>	
21	ORGDP
<u>ORGDP Tails</u>	
22	ORGDP

The tables include the required measured units and basis for results, the number of samples, the arithmetic average (less than values are excluded in averages), and the range of results.

Table 14. Supplemental Analyses for Allied Chemical Natural Feed, CY 1981

Measurement (1)	Units	Basis	Number of Samples (2)	Average	Range
Aluminum	ppm	U	14	<2	All <2
Antimony	ppm	U	14	<5	All <5
Barium	ppm	U	14	<1	All <1
Beryllium	ppm	U	14	<0.2	All <0.2
Bismuth	ppm	U	14	<1	All <1
Boron	ppm	U	14	<0.1	All <0.1
Cadmium	ppm	U	14(1)	0.1	<0.1-0.1
Calcium	ppm	U	14(3)	5	<2-6
Chromium	ppm	U	14	<2	All <2
Cobalt	ppm	U	14	<1	All <1
Copper	ppm	U	14(11)	20	<2-55
Iron	ppm	U	14(2)	9	<5-10
Lead	ppm	U	14	<2	All <2
Lithium	ppm	U	14	<2	All <2
Magnesium	ppm	U	14	<2	All <2
Manganese	ppm	U	14	<2	All <2
Molybdenum	ppm	U	14	<2	All <2
Nickel	ppm	U	14(9)	24	<2-122
Phosphorus	ppm	U	14	<40	All <40
Silicon	ppm	U	14(3)	14	<2-35
Sodium	ppm	U	14(6)	4	<2-10
Tin	ppm	U	14	<2	All <2
Vanadium	ppm	U	14	<2	All <2
Zinc	ppm	U	14	<20	All <20

(1) All analyses by Quantometer spectrochemistry.

(2) The numbers in parentheses reflect the number of analyses in averages. Only quantified results used in averages, i.e., "less than" results are excluded.

Table 15. Supplemental Analyses for BNFL (British) Natural Feed, CY 1981

Measurement (1)	Units	Basis	Number of Samples (2)	Average	Range
Aluminum	ppm	U	6	<2	All <2
Antimony	ppm	U	6	<5	All <5
Barium	ppm	U	6	<1	All <1
Beryllium	ppm	U	6	<0.2	All <0.2
Bismuth	ppm	U	6	<1	All <1
Boron	ppm	U	6	<0.1	All <0.1
Cadmium	ppm	U	6	<0.1	All <0.1
Calcium	ppm	U	6	<2	All <2
Chromium	ppm	U	6	<2	All <2
Cobalt	ppm	U	6	<1	All <1
Copper	ppm	U	6(4)	10	<2-20
Iron	ppm	U	6(1)	25	<5-25
Lead	ppm	U	6	<2	All <2
Lithium	ppm	U	6	<2	All <2
Magnesium	ppm	U	6(1)	3	<2-3
Manganese	ppm	U	6	<2	All <2
Molybdenum	ppm	U	6	<2	All <2
Nickel	ppm	U	6(3)	11	<2-20
Phosphorus	ppm	U	6	<40	All <40
Silicon	ppm	U	6	<2	All <2
Sodium	ppm	U	6	<2	All <2
Tin	ppm	U	6	<2	All <2
Vanadium	ppm	U	6	<2	All <2
Zinc	ppm	U	6	<20	All <20

(1) All analyses by Quantometer spectrochemistry.

(2) The numbers in parentheses reflect the number of analyses in averages. Only quantified results used in averages, i.e., "less than" results are excluded.

Table 16. Supplemental Analyses for Comhurex (French) Natural Feed, CY 1981

Measurement (1)	Units	Basis	Number of Samples (2)	Average	Range
Aluminum	ppm	U	9	<2	All <2
Antimony	ppm	U	9	<5	All <5
Barium	ppm	U	9	<1	All <1
Beryllium	ppm	U	9	<0.2	All <0.2
Bismuth	ppm	U	9	<1	All <1
Boron	ppm	U	9	<0.1	All <0.1
Cadmium	ppm	U	9(1)	0.4	<0.1-0.4
Calcium	ppm	U	9(3)	4.7	<2-8
Chromium	ppm	U	9(2)	16	<2-30
Cobalt	ppm	U	9	<1	All <1
Copper	ppm	U	9(8)	12	<2-25
Iron	ppm	U	9(1)	20	<20-20
Lead	ppm	U	9(1)	3	<2-3
Lithium	ppm	U	9	<2	All <2
Magnesium	ppm	U	9(4)	3	<2-3
Manganese	ppm	U	9	<2	All <2
Molybdenum	ppm	U	9	<2	All <2
Nickel	ppm	U	9(6)	16	<2-40
Phosphorus	ppm	U	9	<40	All <40
Silicon	ppm	U	9	<2	All <2
Sodium	ppm	U	9(2)	6	<2-10
Tin	ppm	U	9	<2	All <2
Vanadium	ppm	U	9	<2	All <2
Zinc	ppm	U	9	<20	All <20

(1) All analyses by Quantometer spectrochemistry.

(2) The numbers in parentheses reflect the number of analyses in averages. Only quantified results used in averages, i.e., "less than" results are excluded.

Table 17. Supplemental Analyses for Eldorado Nuclear Natural Feed,
CY 1981

Measurement (1)	Units	Basis	Number of Samples (2)	Average	Range
Aluminum	ppm	U	16	<2	All <2
Antimony	ppm	U	16	<5	All <5
Barium	ppm	U	16	<1	All <1
Beryllium	ppm	U	16	<0.2	All <0.2
Bismuth	ppm	U	16	<1	All <1
Boron	ppm	U	16	<0.1	All <0.1
Cadmium	ppm	U	16(3)	0.1	<0.1-0.1
Calcium	ppm	U	16(2)	4	<2-5
Chromium	ppm	U	16(2)	2	<2-2
Cobalt	ppm	U	16	<1	All <1
Copper	ppm	U	16(11)	23	<2-110
Iron	ppm	U	16(4)	14	<5-20
Lead	ppm	U	16(5)	12	<2-25
Lithium	ppm	U	16	<2	All <2
Magnesium	ppm	U	16(2)	2	<2-3
Manganese	ppm	U	16(1)	2	<2-2
Molybdenum	ppm	U	16	<2	All <2
Nickel	ppm	U	16(10)	21	<2-155
Phosphorus	ppm	U	16	<40	All <40
Silicon	ppm	U	16(2)	5	<2-7
Sodium	ppm	U	16(9)	6	<2-15
Tin	ppm	U	16(1)	25	<2-25
Vanadium	ppm	U	16	<2	All <2
Zinc	ppm	U	16	<20	All <20

(1) All analyses by Quantometer spectrochemistry.

(2) The numbers in parentheses reflect the number of analyses in averages. Only quantified results used in averages, i.e., "less than" results are excluded.

Table 18. Supplemental Analyses for Kerr-McGee Natural Feed,
CY 1981

Measurement (1)	Units	Basis	Number of Samples (2)	Average	Range
Aluminum	ppm	U	23(1)	2	<2-2
Antimony	ppm	U	23	<5	All <5
Barium	ppm	U	23	<1	All <1
Beryllium	ppm	U	23	<0.2	All <0.2
Bismuth	ppm	U	23	<1	All <1
Boron	ppm	U	23	<0.1	All <0.1
Cadmium	ppm	U	23	<0.1	All <0.1
Calcium	ppm	U	23(1)	3	<2-3
Chromium	ppm	U	23	<2	All <2
Cobalt	ppm	U	23	<1	All <1
Copper	ppm	U	23	18	2-65
Iron	ppm	U	23(3)	14	<5-20
Lead	ppm	U	23(1)	2	<2-2
Lithium	ppm	U	23	<2	All <2
Magnesium	ppm	U	23(4)	4	<2-5
Manganese	ppm	U	23(1)	2	<2-2
Molybdenum	ppm	U	23	<2	All <2
Nickel	ppm	U	23(21)	21	<2-70
Phosphorus	ppm	U	23	<40	All <40
Silicon	ppm	U	23(3)	15	<2-10
Sodium	ppm	U	23(11)	7	<2-30
Tin	ppm	U	23	<2	All <2
Vanadium	ppm	U	23	<2	All <2
Zinc	ppm	U	23	<20	All <20

(1) All analyses by Quantometer spectrochemistry.

(2) The numbers in parentheses reflect the number of analyses in averages.
Only quantified results used in averages, i.e., "less than" results are
excluded.

Table 19. Supplemental Analyses for Comhurex (French) Reactor Returns, CY 1981

Measurement (1)	Units	Basis	Number of Samples (2)	Average	Range
Aluminum	ppm	U	53(6)	3	<2-3
Antimony	ppm	U	53	<5	All <5
Barium	ppm	U	53	<0.1	All <0.1
Beryllium	ppm	U	53	<0.1	All <0.1
Bismuth	ppm	U	53	<1	All <1
Boron	ppm	U	53	<0.1	All <0.1
Cadmium	ppm	U	53(3)	0.1	<0.1-0.12
Calcium	ppm	U	53(18)	3.3	<2-6
Chromium	ppm	U	53(6)	4.2	<2-7
Cobalt	ppm	U	53(1)	3	<1-3
Copper	ppm	U	53(46)	12	<2-40
Dysprosium	ppm	U	53	<0.2	All <0.2
Gadolinium	ppm	U	53	<0.2	All <0.2
Iron	ppm	U	53(16)	14	<5-60
Lead	ppm	U	53(12)	3.3	<2-5
Lithium	ppm	U	53	<2	All <2
Magnesium	ppm	U	53(3)	2.3	<2-3
Manganese	ppm	U	53	<2	All <2
Molybdenum	ppm	U	53	<2	All <2
Nickel	ppm	U	53(42)	16	<2-95
Phosphorus	ppm	U	53	<40	All <40
Samarium	ppm	U	53	<0.4	All <0.4
Silicon	ppm	U	53(24)	6.1	<2-15
Sodium	ppm	U	53(37)	3.5	<2-25
Technetium	ppm	U	53(41)	0.044	<0.006-0.15
Thorium	ppm	U	53	<1	All <1
Tin	ppm	U	53	<2	All <2
Vanadium	ppm	U	53	<2	All <2
Zinc	ppm	U	53	<20	All <20

(1) All analyses by Quantometer spectrochemistry, except Dy, Gd, Sm, Tc, and Th.

(2) The numbers in parentheses reflect the number of analyses in averages. Only quantified results used in averages, i.e., "less than" results are excluded.

Table 20. Supplemental Analyses for Enriched Feed, CY 1981

Measurement ⁽¹⁾	Units	Basis	Number of Samples ⁽²⁾	Average	Range
Aluminum	ppm	U	9	<2	All <2
Antimony	ppm	U	9	<5	All <5
Barium	ppm	U	9	<1	All <1
Beryllium	ppm	U	9	<0.2	All <0.2
Bismuth	ppm	U	9	<1	All <1
Boron	ppm	U	9	<0.1	All <0.1
Cadmium	ppm	U	9(2)	0.44	<0.1-0.45
Calcium	ppm	U	9	<2	All <2
Chromium	ppm	U	9	<2	All <2
Cobalt	ppm	U	9	<1	All <1
Copper	ppm	U	9(8)	6.1	<2-15
Iron	ppm	U	9(1)	6	<5-6
Lead	ppm	U	9	<2	All <2
Lithium	ppm	U	9	<2	All <2
Magnesium	ppm	U	9	<2	All <2
Manganese	ppm	U	9	<2	All <2
Molybdenum	ppm	U	9	<2	All <2
Nickel	ppm	U	9(5)	8	<2-15
Phosphorus	ppm	U	9	<40	All <40
Silicon	ppm	U	9(1)	5	<2-5
Sodium	ppm	U	9	2.2	2-4
Tin	ppm	U	9	<2	All <2
Vanadium	ppm	U	9	<2	All <2
Zinc	ppm	U	9	<20	All <20

(1) All analyses by Quantometer spectrochemistry.

(2) The numbers in parentheses reflect the number of analyses in averages. Only quantified results used in averages, i.e., "less than" results are excluded.

Table 21. Supplemental Analyses for ORGDP Product, CY 1981

Measurement (1)	Units	Basis	Number of Samples (2)	Average	Range
Aluminum	ppm	U	9(1)	3	<2-3
Antimony	ppm	U	9	<5	All <5
Barium	ppm	U	9	<0.1	All <0.1
Beryllium	ppm	U	9	<0.1	All <0.1
Bismuth	ppm	U	9	<1	All <1
Boron	ppm	U	9	<0.1	All <0.1
Cadmium	ppm	U	9	<0.1	All <0.1
Calcium	ppm	U	9(2)	5.5	<2-6
Chromium	ppm	U	9(1)	3	<2-3
Cobalt	ppm	U	9(2)	1.5	<1-2
Copper	ppm	U	9(8)	11	<2-25
Dysprosium	ppm	U	9	<0.2	All <0.2
Gadolinium	ppm	U	9	<0.2	All <0.2
Iron	ppm	U	9	<5	All <5
Lead	ppm	U	9(1)	3	<2-3
Lithium	ppm	U	9	<2	All <2
Magnesium	ppm	U	9(1)	2	<2-2
Manganese	ppm	U	9	<2	All <2
Molybdenum	ppm	U	9	<2	All <2
Nickel	ppm	U	9	17	5-25
Phosphorus	ppm	U	9	<40	All <40
Samarium	ppm	U	9	<0.4	All <0.4
Silicon	ppm	U	9(1)	5	<2-5
Sodium	ppm	U	9(5)	3	<2-3
Technetium	ppm	U	9	0.064	<0.008-0.16
Thorium	ppm	U	9	<1	All <1
Tin	ppm	U	9	<2	All <2
Vanadium	ppm	U	9	<2	All <2
Zinc	ppm	U	9	<20	All <20

(1) All analyses by Quantometer spectrochemistry, except Dy, Gd, Sm, Tc, and Th.

(2) The numbers in parentheses reflect the number of analyses in averages. Only quantified results used in averages, i.e., "less than" results are excluded.

Table 22. Supplemental Analyses for ORGDP Tails, CY 1981

Measurement (1)	Units	Basis	Number of Samples (2)	Average	Range
Aluminum	ppm	U	16(4)	3	<2-5
Antimony	ppm	U	16	<5	All <5
Barium	ppm	U	16	<1	All <1
Beryllium	ppm	U	16	<0.2	All <0.2
Bismuth	ppm	U	16	<1	All <1
Boron	ppm	U	16	<0.1	All <0.1
Cadmium	ppm	U	16(6)	0.2	<0.1-0.3
Calcium	ppm	U	16(2)	4	<2-5
Chromium	ppm	U	16(2)	6	<2-8
Cobalt	ppm	U	16	<1	All <1
Copper	ppm	U	16	13	2-45
Iron	ppm	U	16(5)	7	<5-15
Lead	ppm	U	16(1)	2	<2-2
Lithium	ppm	U	16	<2	All <2
Magnesium	ppm	U	16(9)	3	<2-4
Manganese	ppm	U	16(1)	2	<2-2
Molybdenum	ppm	U	16	<2	All <2
Nickel	ppm	U	16	23	2-80
Phosphorus	ppm	U	16	<40	All <40
Silicon	ppm	U	16	<2	All <2
Sodium	ppm	U	16(8)	4	<2-5
Soluble Impurities	°C	[Lowering of freezing point]	10	0.097	0.008-0.291
Tin	ppm	U	16	<2	All <2
Vanadium	ppm	U	16	<2	All <2
Zinc	ppm	U	16	<20	All <20

(1) All analyses by Quantometer spectrochemistry.

(2) The numbers in parentheses reflect the number of analyses in averages. Only quantified results used in averages, i.e., "less than" results are excluded.

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